

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
22 February 2001 (22.02.2001)

PCT

(10) International Publication Number
WO 01/13625 A1

(51) International Patent Classification⁷: H04N 5/00, 7/26

(21) International Application Number: PCT/US00/40659

(22) International Filing Date: 16 August 2000 (16.08.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/149,267 17 August 1999 (17.08.1999) US

(71) Applicant (for all designated States except US): GEN-
ERAL INSTRUMENT CORPORATION [US/US]; 101
Tournament Drive, Horsham, PA 19044 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): MORONEY, Paul
[US/US]; 3411 Western Springs Road, Olivenhain, CA
92009 (US).

(74) Agent: LIPSITZ, Barry, R.; Law Offices of Barry R. Lip-
sitz, Building No. 8, 755 Main Street, Monroe, CT 06468
(US).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU,
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ,
DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR,
HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR,
LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ,
NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM,
TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

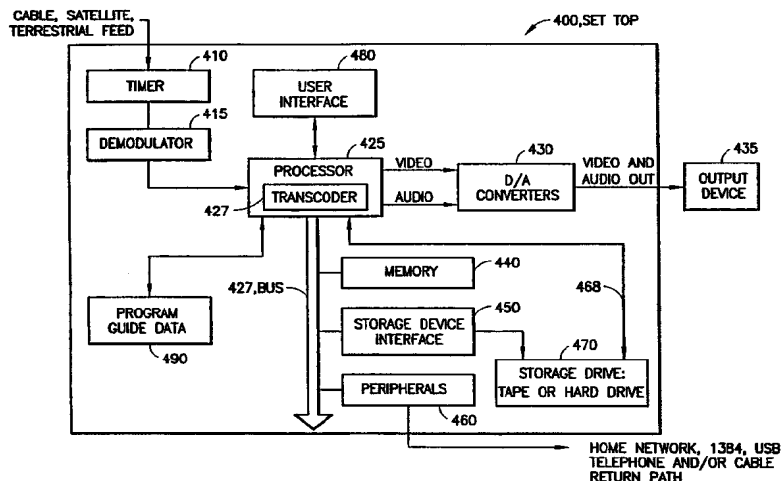
(84) Designated States (*regional*): ARIPO patent (GH, GM,
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian
patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European
patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,
IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG,
CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

- With international search report.
- Before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments.

For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: TRANSCODING FOR CONSUMER SET-TOP STORAGE APPLICATION



(57) Abstract: A consumer set-top terminal (400) and method that receives and stores digital programming services such as television programs for subsequent playback by the user in a manner analogous to a conventional video cassette recorder (VCR). An interface (480) allows the terminal's user to control a transcoding process (427) based on the desired quality level for the transcoded data, e.g., high, medium or low. The transcoding is provided without the expense and complexity of a full encoder. By performing transcoding at the terminal (400), the bit rate of the data can be reduced sufficiently to allow economical storage at the terminal. Moreover, the user can set the quality level to be different for different programs, different parts of the same program, or for different channels.



WO 01/13625 A1

TRANSCODING FOR CONSUMER SET-TOP STORAGE APPLICATION**BACKGROUND OF THE INVENTION**

This application claims the benefit of U.S.
provisional application no. 60/149,267, filed August
5 17, 1999.

The present invention relates to a consumer set-
top terminal that receives and stores digital
programming services such as television programs for
subsequent playback by the user.

10 Recently, a new product family has emerged in the set-
top industry based upon hard drives inside set-top
boxes. These drives are used to store video programs
much as with a video cassette recorder (VCR), but
without the removeability of the tape media. These
15 devices are extremely expensive, as they include MPEG
encoders to process incoming analog television signals
for storage on the hard drive in a compressed,
digitized format.

Once the expected transition to all digital
20 programming services is made in the industry, the set-
top plus hard drive can store video at a far lower
cost, because no encoder sub-system would be required.
The bits received from the incoming transmissions

would simply be stored as they are received, as MPEG transport packets. Unfortunately, the incoming digital rates are set by the source video providers and, in MPEG-2 systems, for instance, can range from
5 about 1.5 Mbps up to 15 Mbps. To the consumer, this will translate to storage capacities that are unpredictable and uncontrollable. Moreover, no quality setting is possible, and the disk will have to be sized big enough to store a program at its highest
10 bitrate of 15 Mbps, which may result in use of an oversize hard drive, thereby raising costs. It will at least produce less useable capacity and confuse the consumer.

Accordingly, it would be desirable to provide an
15 approach to set-top storage for all-digital inputs that solves this problem, that is still low cost, yet provides the consumer with a quality/storage capacity choice that is analogous to a VCR.

The system should allow a user to store one or
20 more programs at a set-top terminal for subsequent playback at the user's convenience.

The system should store the received programming in a compressed format to reduce the required storage capacity. In particular, the system should provide a
25 transcoder at the terminal to transcode received

programming that is already compressed and digitized, e.g., to transcode to a reduced bit rate.

Furthermore, the transcoding should be responsive to a user-determinable parameter, such as desired quality level for the programming. In this manner, the user can control the amount of storage space that is used by the transcoded programs.

Optionally, it would further be desirable to provide a user interface such as an on-screen program guide to assist the user in storing the programs.

The interface should provide functions that are similar to a conventional video cassette recorder (VCR) which store programs in an analog format. These functions include, e.g., play, fast forward, rewind, fast rewind, pause, and incremental (scan) forward and reverse.

The system should be implementable at a relatively low cost which is economically feasible for mass-produced consumer set-top devices. The system should be implementable within a set-top device or as a peripheral to a set-top device.

The present invention provides a system having the above and other advantages.

SUMMARY OF THE INVENTION

The present invention relates to a consumer set-top terminal that receives and stores digital programming services such as television programs for subsequent playback by the user.

In particular, the invention provides an application of transcoding to consumer products that store video, e.g., on hard drives or on tape, where the storage and playback behavior correspond to that expected by a consumer from existing devices, such as VCRs, and at a relatively low cost.

The present invention provides a transcoder at a terminal that transcodes the received compressed data to a compressed format, e.g., with a lower bit rate, in accordance with a user-selectable parameter. For example, the user can select a high, medium or low quality level for transcoding that is analogous to the use of an analog VCR tape in different time storage modes, e.g., two, four or six hours, respectively.

For this analogy, note that, in the two hour mode, the analog tape moves relatively fast so that a given amount of data is stored in a larger tape area, resulting in a higher quality. Conversely, in the six hour mode, the analog tape moves relatively slowly so

that a given amount of data is stored in a smaller
tape area, resulting in a lower quality. Again, this
is an analogy only that relates the digital storage of
the present invention to the analog tape concept that
5 may be more readily understood by the user. For
digital storage, each data bit is stored, and the
quality is related to the number of bits that
represent an image.

For this digital storage, any type of storage
10 device can be used, such as a hard drive, floppy disk
drive, magnetic tape, or optical storage media (DVD,
CD, laser disc). Moreover, the storage medium may be
removable by the user. Thus, when the medium become
full, the user can insert a replacement.

15 By selecting the quality level, the user
therefore has an idea of the amount of storage that
will be consumed when storing a program.
Additionally, the user has the option of storing
particularly favorite programs at a higher quality.
20 For example, a user may desire to store a movie with
special effects with a high quality, while a sports
event is stored at a medium quality, and a news
program or lecture is stored at a lower quality. Of
course, even the lower quality should provide an
25 acceptable viewing experience. Thus, the quality

level is a relative term, not an absolute one.

The invention thus uses transcoding at a user terminal, which is present in a user's home or business, for example, to provide additional features and functions to the user. This enhances the user's enjoyment and convenience. The revenues of the system operator are also enhanced since these features will attract new subscribers to the network, and lead the users to order additional programming at an additional cost.

A particular method for storing data at a user terminal from a compressed digital data stream received thereat, includes the step of transcoding at least a portion of the received data stream at the terminal to provide corresponding transcoded data. The transcoded data is stored at a storage device associated with the terminal. Additionally, a user input is received that is indicative of a desired transcoding parameter, where the transcoding step is responsive to the desired transcoding parameter.

A corresponding user terminal is also presented.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a prior art approach which combines a full decoder with a full encoder.

5 FIG. 2 illustrates an efficient transcoder which removes motion estimation processing.

FIG. 3 illustrates a method for transcoding data at a terminal in response to a user input in accordance with the present invention.

10 FIG. 4 illustrates a user terminal in accordance with the present invention.

FIG. 5(a) illustrates a first on-screen display of a user interface in accordance with the present invention.

15 FIG. 5(b) illustrates a second on-screen display of a user interface in accordance with the present invention.

FIG. 5(c) illustrates a third on-screen display of a user interface in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a consumer set-top terminal that receives and stores digital programming services such as television programs for subsequent playback by the user.

5 The primary concept blends the concepts of low cost transcoding developed with the needs of a set-top terminal that is equipped with a storage device such as a hard drive. Transcoding is defined as a reprocessing of compressed video from one rate to
10 another, and/or from one resolution to another (for example HD TV to SD TV), or from one standard to another (for example MPEG-1 to MPEG-2). This discussion will focus on the first of these (i.e., bit rate transcoding), as it holds the highest potential
15 of retaining a very low cost, but the ideas apply generally to any type of transcoding.

 For purposes of the present disclosure, transcoding is defined as decoding a compressed signal only to the extent necessary to effect requantization,
20 and then performing only those encoding steps necessary to produce a lower rate bit stream from the requantized data. The intent is to provide a lower rate signal without the high cost and complexity of a

full encoder, and potentially without a full decoder, at the user terminal. The lower the rate, the more reduction in quality occurs.

5 The decoding/re-encoding sequence could be performed by combining in tandem a full decoder with a full encoder as was provided in the prior art (FIG. 1), but this approach requires an expensive encode sub-system. In addition, quality suffers even more when such a process is used, due to the full decoding and re-encoding steps performed. In accordance with 10 the present invention, the decode/encode tandem approach is simplified to eliminate many steps, and furthermore, many of the decisions made by the original encoder (at the source) are known for the purposes of decoding, and can thus be reused, again 15 saving complexity and cost.

A primary benefit results from reusing the motion estimation process (i.e., reusing motion vectors to avoid the need for motion estimation in the transcoder - FIG. 2), which is arguably the most expensive part 20 of the overall encode process. This reuse tends to also maintain the block types (I, P, B) during transcoding; otherwise, the motion vectors may not be applicable at all. Other decisions can be reused as well, such as field/frame mode. 25

While the invention may be used with any transcoding scheme, the transcoding schemes described in U.S. Patent 5,619,733 and in Wang, L. et al., "Adaptive Rate Control for MPEG Transcoder", 1999 *IEEE International Conference on Image Processing*, Kobe, Japan, 28 October 1999, for example, are well suited for use with the techniques described herein.

FIG. 1 illustrates the prior art technique of providing a full decoder cascaded with a full encoder for an MPEG bitstream. The cascaded components first decode a compressed bitstream, e.g. that is obtained from a library or transmission source, to obtain a reconstructed video sequence. The reconstructed video sequence is then re-encoded by a conventional encoder to obtain a different compressed bitstream that is suitable for transmission, e.g., to a decoder population.

In particular, the prior art approach used a decoder 110 and a full encoder 150. A pre-compressed video bitstream is input to a Variable Length Decoder (VLD) 115. A dequantizer function 120 processes the output of the VLD 115 using a first quantization step size, Q_1 . An Inverse Discrete Cosine Transform (IDCT) function 125 processes the output of the inverse quantizer 120 to provide pixel domain data to an adder

130. This data is summed with either a motion compensation difference signal from a Motion Compensator (MC) 135 or a null signal, according to the position of a switch 140.

5 The code mode for each input macroblock (MB), either intra or inter mode, embedded in the input pre-compressed bit stream, is provided to the switch 140. The output of the adder 130 is provided to the encoder 150 and to a Current Frame Buffer (C_FB) 145 of the
10 decoder 110. The MC function 135 uses data from the current FB 145 and from a Previous Frame Buffer (P_FB) 150 along with motion vector (MV) data from the VLD 115.

 In the encoder 150, pixel data is provided to an
15 intra/inter mode switch 155, an adder 160, and a Motion Estimation (ME) function 165. The switch 155 selects either the current pixel data, or the difference between the current pixel data and pixel data from a previous frame, for processing by a
20 Discrete Cosine Transform (DCT) function 170, quantizer 175, and Variable Length Coding (VLC) function 180. The output of the VLC function 180 is a bitstream that is transmitted to a decoder. The
25 bitstream includes Motion Vector (MV) data from the ME function 165.

Note that the quantizer uses a quantization level Q_2 that could be controlled by a user input, although this approach has the disadvantage of the
aforementioned high cost and complexity of the prior
5 art. In such an embodiment, the bit output rate would be adjusted by changing Q_2 .

In a feedback path, processing at an inverse quantizer 182 and an inverse DCT function 184 is performed to recover the pixel domain data. This data
10 is summed with motion compensated data or a null signal at an adder 186, and the sum thereof is provided to a Current Frame Buffer (C_FB) 190. Data from the C_FB 190 and a P_FB 192 are provided to the ME function 165 and a MC function 194. A switch 196
15 directs either a null signal or the output of the MC function 194 to the adder 186 in response to an intra/inter mode switch control signal.

This approach is computationally intensive due to the full decompression of the pre-compressed data to
20 the pixel domain, and the full re-compressing of the intermediate reconstructed video frames, including motion compensation and estimation processing for the inter-frame coded data. Additionally, the implementation cost of the cascaded decoder and

encoder is relatively high due to the need for one full MPEG decoder and one full MPEG encoder.

Computer simulation results have indicated that if the picture type for each frame is maintained, the motion vectors decoded from the decoder can be used for motion compensation in the encoder without significantly impairing the perceptual quality of the resulting image. This indicates that motion estimation, the most expensive operation, can be removed from the cascaded decoder/encoder approach of the prior art. Such a scheme, in accordance with the present invention, is discussed in connection with FIG. 2, below.

FIG. 2 illustrates a transcoder in accordance with the invention wherein motion estimation has been removed from the encoder. Like-numbered elements correspond to the elements of FIG. 1. The transcoder 200 includes a decoder section generally designated 210 and portions of an encoder (preferably only those portions necessary to produce a lower rate bit stream from the requantized data), generally designated 250. Here, the motion vectors from the VLD 115 are provided to the MC 194 in the encoder 250.

The transcoder architecture of FIG. 2 will therefore generate a new bitstream and a new bit rate,

but with the same video format block types (i.e., predicted and non-predicted) and other parameters, and therefore the same motion vectors, as the incoming compressed bitstream.

5 Again, while FIG. 2 discloses a particularly efficient transcoder, the invention is compatible with essentially any known bit rate transcoder, and provides more efficient transcoding. The much simplified transcoder approach disclosed herein (and
10 even simpler forms) can be implemented at low cost, and obviates the requirement for discrete decoder and encoder devices. Moreover, full software digital signal processor (DSP) implementations are feasible with the simplified approach of the present invention.

15 The set-top design can operate as follows. The consumer may choose from among a number of quality levels, e.g., three, for storage. For example, a high quality mode (analogous to using an analog video tape in a two hour mode), a medium quality mode (analogous
20 to using an analog video tape in a four hour mode), or low quality mode (analogous to using an analog video tape in a six hour mode).

 As mentioned, the received bitstream may come in to the terminal at 15 Mbps, if we presume the case of
25 standard resolution TV (MPEG-2 main level main

profile). Thus, for each quality level, the received
bitstream must be transcoded down to the rate that
fits the program into the right amount of storage
capacity. Consider the specific case of a program
5 such as a movie received at 15 Mbps, and transcoded in
real time down to either 6 Mbps, 3 Mbps, or 2 Mbps.
For illustration, assume the storage device at the
terminal is a hard drive with a 6 GB capacity. At the
highest video quality setting (transcoding down to 6
10 Mbps), the consumer could store 2.2 hours of video,
i.e., $(6 \text{ Gbytes} \times 8 \text{ bits/bytes}) / 6 \text{ Mbits/sec} = 8,000$
sec. = 133 minutes = 2:13 hours. At medium quality,
the consumer could store 4.4 hours of programming, and
at the lowest quality setting, the consumer could
15 store 6.6 hours of programming.

Note that the transcoding is easily capable of
variable bit rate compression, so that it is not
necessary to code to exactly 6, or 4, or 2 Mbps for
each case, but only to an average rate over the entire
20 program. Variable rate coding produces far greater
quality than fixed rate coding would, given equal
average rates. Digital video disc (DVD) movies are
examples of variable rate coded programs. A DVD movie
with a two hour run time is stored at an average rate

of about 5 Mbps, but can have peaks as high as 10 Mbps, when the scene demands it.

If desired, however, the user could set a fixed bit rate for the transcoding.

5 Note that the user input, which sets the transcoding quality level via a mechanism we refer to as a "quality dial," is arbitrary, as transcoding can produce whatever bit rate one wishes. The bit rate can even be continuously adjustable, although the
10 consumer may not be comfortable with such a dial, being so different from the VCR experience of the last 30 years.

 The consumer may also view the transcoded program during reception thereof. Then, the user may select
15 an increased quality level for subsequent portions of a movie, for example. As another example, a user viewing an educational program may wish to enhance the quality of subsequent images, e.g., for a doctor viewing a surgery, or for a hobbyist viewing a sewing
20 program, or for a student viewing a slide that is displayed in a lecture. The quality level can then be reduced by the user once the critical segments have passed.

A minimum or floor bit rate may be enforced by the terminal to maintain some minimum image quality that is acceptable to most viewers.

Similarly, a maximum or ceiling bit rate can
5 correspond to the bit rate of the received data at the terminal, or to some predetermined lower level. Generally, transcoding to a higher bit rate is not useful.

FIG. 3 illustrates a method for transcoding data
10 at a terminal in response to a user input in accordance with the present invention.

At block 300, compressed digital programs, which may comprise MPEG transport packets or an Internet Protocol (IP)-delivered media stream, for instance,
15 are buffered in a memory at the user terminal. Generally, digital programs can be of any format in terms of spatial resolution, frame rate, color sampling, interlaced/progressive, etc.; and they can be pre-encoded at any rate, either constant bit rate
20 (CBR) or variable bit rate (VBR).

At block 310, the buffered data is transcoded based on a user input. The buffered data may be requantized using existing motion vectors and other parameters under an appropriate rate control scheme to
25 achieve a new rate.

The user input may comprise a desired quality or the analogous concept of an analog VCR tape record time, as discussed previously.

At block 320, the transcoded data is again
5 buffered in a memory, and at block 330, the transcoded data is transferred, e.g., through a disk or tape interface, to a storage device to be stored for later playback by the user.

FIG. 4 illustrates a user terminal in accordance
10 with the present invention.

The terminal 400 receives compressed digital programming at a tuner 410, e.g., via a cable satellite or terrestrial feed. The received signal is demodulated at a demodulator 415 and provided to a
15 processor 425, which may be implemented using hardware, firmware and/or software. The processor 425 includes a low cost transcoder 427, which may be the transcoder 200 of FIG. 2, or any other suitable design.

20 For maximum flexibility, the processor 425 should be capable of decoding digital video, such as MPEG-2 video in a conventional manner, and also of transcoding video in accordance with the invention. Note that low cost transcoding is between 1.5 and 2
25 times more complex than pure decoding.

The processor may also provide various functions for the playback of the stored video, including trick modes such as fast forward, pause, slow scan, and so on, which are all effects that are expected by the consumer who is familiar with the age-old VCR. A path
5 468 enables the processor 425 to retrieve the stored data from the storage device 470 for playback.

It should also be appreciated that the identical approach applies to the case of true removable storage
10 media, such as tape or advanced floppy disks, or even removable hard media. Such a product could produce the exact experience of a VCR.

The processor 425 also communicates with a user interface 480 for receiving the user input for
15 transcoding, and a program guide data function 490.

The optional program guide data function 490 receives data, typically with the programming services, for providing a graphical display of a schedule for the programs that are playing currently
20 and in the near future. In accordance with the invention, and as discussed further in connection with FIGs 5(a)-(c), this data can be used to enable the user to select a program to transcode and store.

The processor 425 may decode and output digital
25 video and audio to a D/A converter 430 to provide

corresponding analog signals which are, in turn, provided to an output device 435, such as a television with speakers.

5 A bus 427 allows the processor 425 to communicate with a memory 440, which may buffer the received data prior to and following transcoding, a storage device interface 450, which formats the transcoded data for storage at the storage device 470 (e.g., tape or hard drive), and optional peripherals 460, which may route
10 data to a home network, an IEEE 1394 interface, a universal serial bus (USB), a telephone line, and/or cable return paths.

Note that the transcoding functionality (e.g., circuitry and other components) can be provided in a
15 single set-top terminal, although this is not required. The functionality can also be provided, in whole or in part, in a peripheral device. Any such peripheral device is considered to be part of the terminal apparatus 400.

20 FIG. 5(a) illustrates a first on-screen display of a user interface in accordance with the present invention.

The display 500 is generated from the program guide data function 490 of FIG. 4 in a known manner.
25 The display lists various programs that are available

on the different channels. For example, the available channels include "ABC", "TRAVEL", "PPV" (pay-per-view), and "FOX". Typically, the guide 500 can be scrolled to the left or right to view different program times, and up or down to view additional channels. This may be accomplished by the user, e.g., via a hand-held remote control, voice control interface, or other means.

FIG. 5(b) illustrates a second on-screen display of a user interface in accordance with the present invention.

Here, assume the user has selected the program entitled "CRUISES" from the "TRAVEL" channel, which runs from 8 pm to 10 pm. The display 550 informs the user of his selection, and asks him whether he would like to view the program only, record it only, both view and record, or exit the screen. The user can make his choice again using the hand-held remote control.

FIG. 5(c) illustrates a third on-screen display of a user interface in accordance with the present invention.

The display 580 confirms that the user has chosen to record the program "CRUISES", and that the run time is two hours. The user is then asked to select a

record quality, e.g., high, medium, or low, or to exit the screen. The user can make his choice again using the hand-held remote control, given displayed estimates of available storage space.

5 Note that the user input for controlling the transcoding can be described in a variety of ways in the interface. For example, the analogous VCR tape record time can be expressed, e.g., 2, 4 or 6 hours. Moreover, for marketing purposes, the high, medium or
10 low quality can be expressed as "super", "enhanced", and "standard" qualities, respectively, or the like. The quality level can also be expressed on a numeric scale, such as from 1-10.

 Note that an on-screen interface is not required
15 to receive the user input for transcoding. Various other interface options are possible, such as a mechanical dial ("quality dial") or switch. Or, a separate display can be provide in the hand-held interface that indicates the quality level settings
20 using know techniques to communicate from the set-top to the remote control.

 Another option is for the user to input a desired default quality level beforehand such that any program that is subsequently recorded is transcoded at the
25 corresponding quality level. Appropriate data can be

stored at the terminal for this purpose. A further related option is for the desired quality level to be stored for particular channels. For example, the user may desire to have a high quality for the "PPV" channel, and a medium quality for all other channels.

5 Thus, the user input for a program can be established prior to transcoding and storing. Moreover, the user input can designate respective desired transcoding parameters for corresponding specified channels prior to the transcoding and storing.

10 It is also possible for the user to designate that a program is to be stored prior to the run time of the program.

15 Moreover, as mentioned, the user may dynamically change the quality level as the transcoding (and concurrent display of the transcoded program) progresses. To this end, it may be desirable to provide an on-screen display of a small icon in the corner of the TV screen that indicates the currently-set quality level.

20 Accordingly, it can be seen that the present invention provides a consumer set-top terminal that receives and stores digital programming services such as television programs for subsequent playback by the

25

user in a manner analogous to a conventional video cassette recorder (VCR). An interface allows a user to control the transcoding based on the desired quality level for the transcoded data, e.g., high, 5 medium or low. By performing transcoding at the terminal, the bit rate of the data can be reduced sufficiently to allow economical storage at the terminal. Moreover, the user can set the quality level to be different for different programs, or for 10 different channels. The user input can be received via an interface, such as an on-screen display, which is optionally integrated with electronic program guide data.

Although the invention has been described in connection with various preferred embodiments, it should be appreciated that various modifications and adaptations may be made thereto without departing from the scope of the invention as set forth in the claims.

What is claimed is:

1. A method for storing data at a user terminal from a compressed digital data stream received thereat, comprising the steps of:

receiving a user input that is indicative of a desired transcoding parameter;

transcoding at least a portion of the received data stream at the terminal in accordance with the desired transcoding parameter to provide corresponding transcoded data; and

storing the transcoded data at a storage device associated with the terminal;
wherein the stored transcoded data is available for subsequent playback by the user.

2. The method of claim 1, wherein:

the transcoding parameter comprises a quality level for the transcoded data that is selected by the user from a plurality of available quality levels.

3. The method of claim 2, wherein:

the desired quality level designates a quantization level used in said transcoding step.

4. The method of claim 1, wherein:
the transcoding parameter comprises a resolution for the transcoded data that is selected by the user from a plurality of available resolutions.

5. The method of claim 4, wherein:
the transcoded data comprises television data;
and
the plurality of available resolutions comprise standard definition television (SDTV) and high-definition television (HDTV).

6. The method of claim 1, wherein:
the transcoding parameter comprises a format for the transcoded data that is selected by the user from a plurality of available formats.

7. The method of claim 1, wherein:
the transcoding parameter comprises a bit rate for the transcoded data that is selected by the user from a plurality of available bit rates; and
the transcoded data is provided at a variable bit rate that corresponds, when averaged, to the user-selected bit rate.

8. The method of claim 1, wherein:

the transcoding parameter comprises a bit rate for the transcoded data that is selected by the user from a plurality of available bit rates; and the transcoded data is provided at a substantially constant bit rate that corresponds to the user-selected bit rate.

9. The method of claim 1, wherein:

the received data stream comprises at least one of audio and video data.

10. The method of claim 1, wherein the transcoding step:

decodes the received data stream to only the extent necessary to effect requantization; and

performs only the encoding steps necessary to produce a lower rate bit stream from the data after requantization.

11. The method of claim 10, wherein the encoding does not perform motion estimation.

12. The method of claim 1, comprising the further step of:

decompressing at least one of the received data or the transcoded data stream to obtain decompressed data, and providing the decompressed data to an output device concurrently, at least in part, with said transcoding step.

13. The method of claim 1, wherein the received data stream and the corresponding transcoded data comprise at least one video and/or audio program, comprising the further steps of:

providing guide data for presenting an on-screen display to inform the user of the availability of the program; and

enabling the user input to be provided in accordance with the on-screen display.

14. The method of claim 1, comprising the further step of:

providing a user interface for informing the user of the plurality of available transcoding parameters, and for receiving the user input.

15. The method of claim 1, comprising the further step of:
providing a user interface for receiving the user input.

16. The method of claim 15, wherein:
the user interface is an on-screen interface.

17. The method of claim 1, wherein:
the received data stream comprises MPEG transport packets.

18. The method of claim 1, wherein:
the received data stream comprises an Internet Protocol-delivered media stream.

19. The method of claim 1, wherein:
the storage device comprises at least one of a hard drive and a tape.

20. The method of claim 1, wherein:
the storage device comprises a user-removable storage medium.

21. The method of claim 1, wherein:
the user terminal comprises a set-top box.

22. A user terminal for storing data from a
compressed digital data stream received thereat,
comprising:

an interface for receiving a user input that is
indicative of a desired transcoding parameter for the
data stream;

a transcoder responsive to said user input for
decoding the data stream to the extent necessary to
effect requantization thereof and for performing the
encoding steps necessary to produce a lower rate bit
stream from the data after requantization, thereby
providing transcoded data dependent on said user
input; and

a storage device for storing the transcoded data;
wherein the stored transcoded data is available
for subsequent playback by the user.

23. A user terminal in accordance with claim 25,
wherein said encoding steps do not perform motion
estimation.

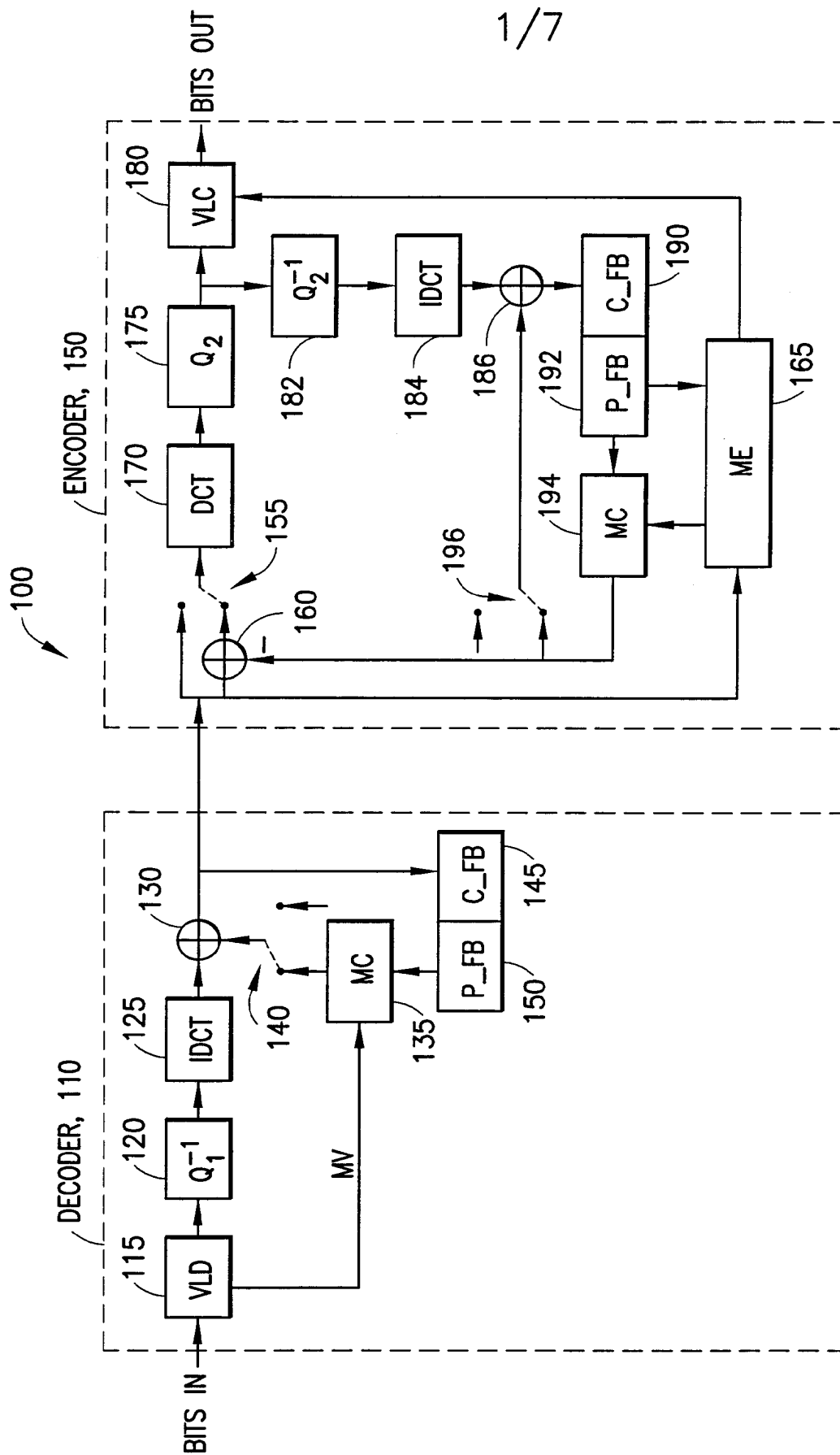


FIG. 1
PRIOR ART

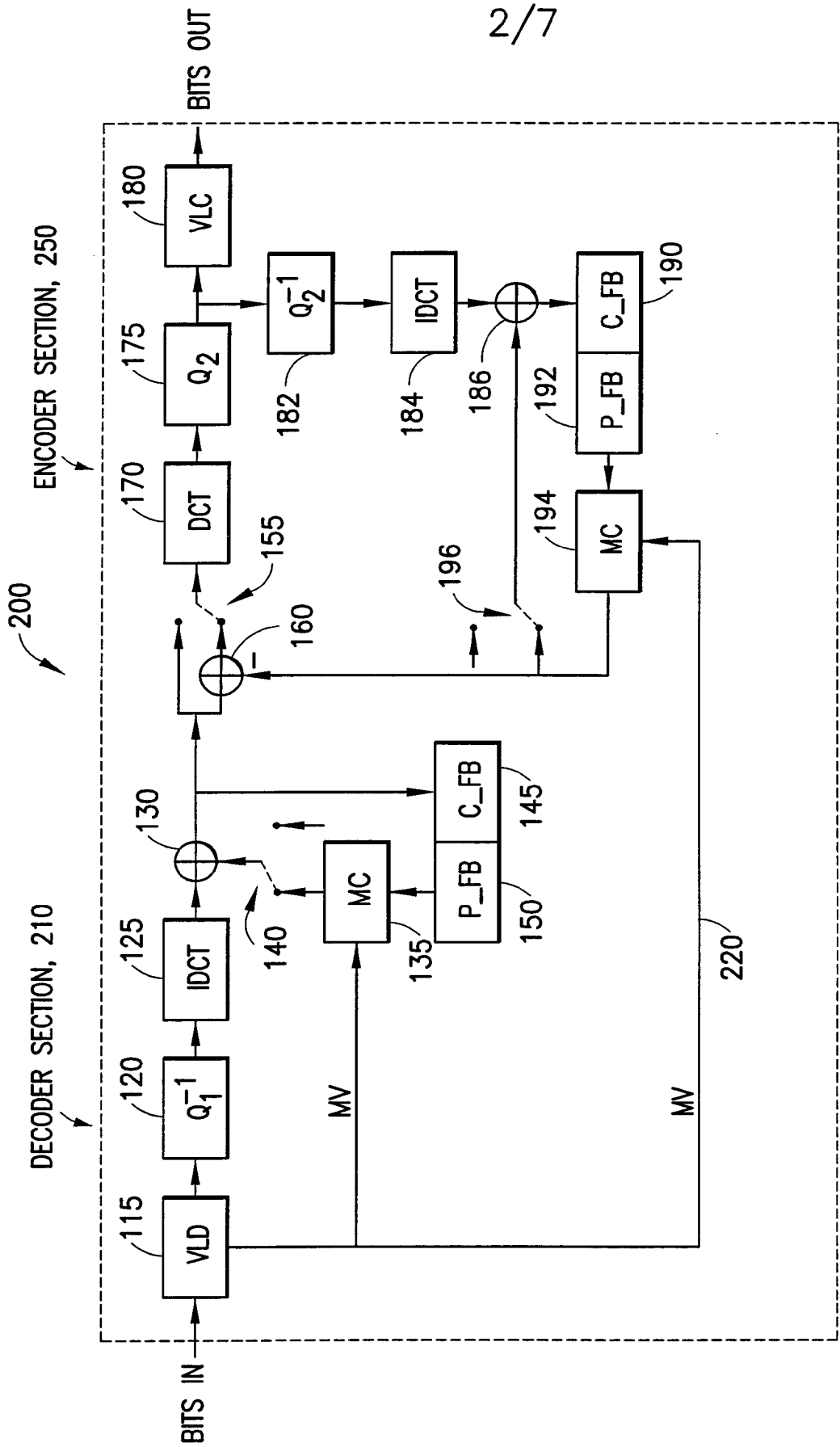


FIG.2

3/7

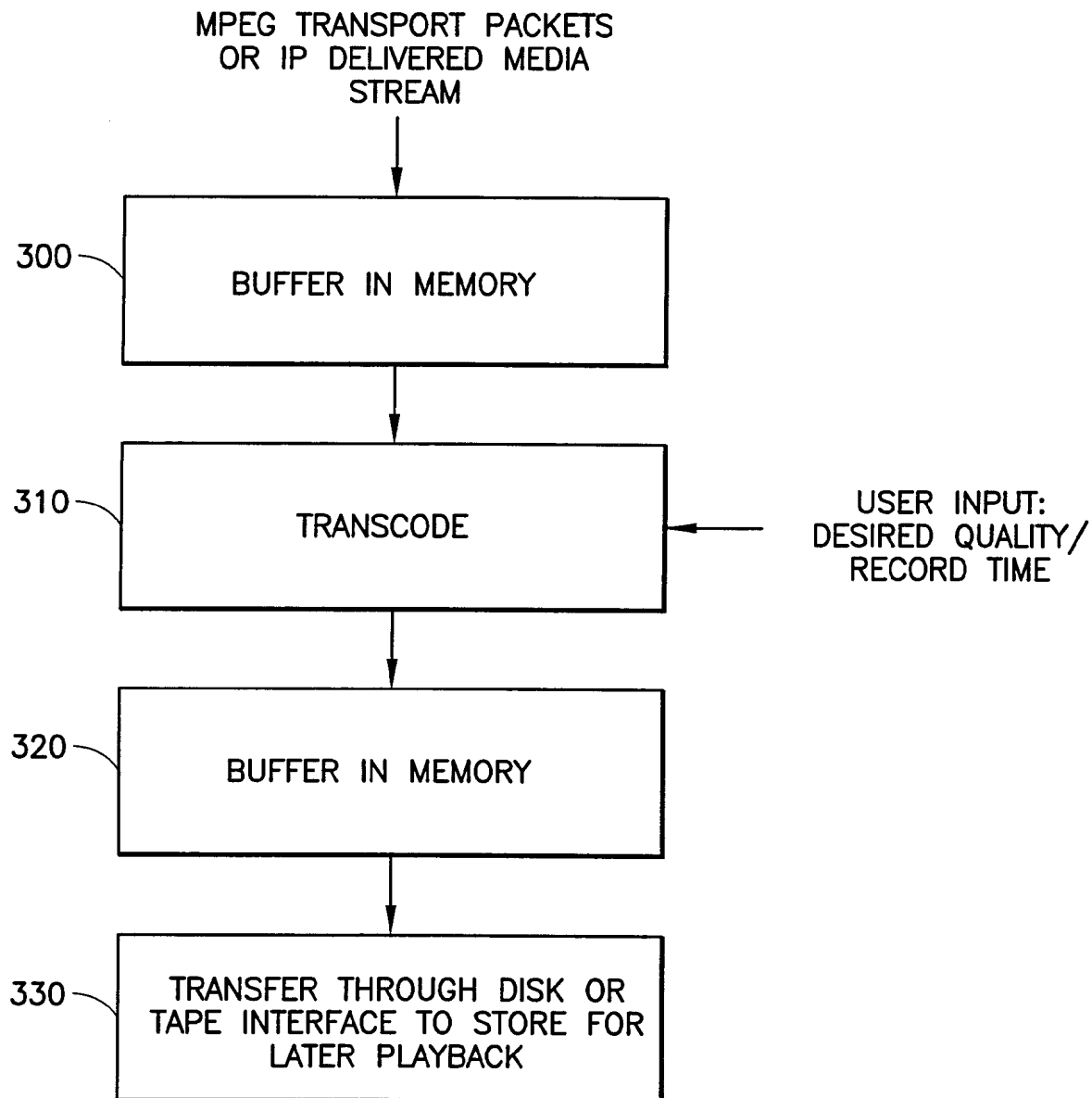


FIG.3

4/7

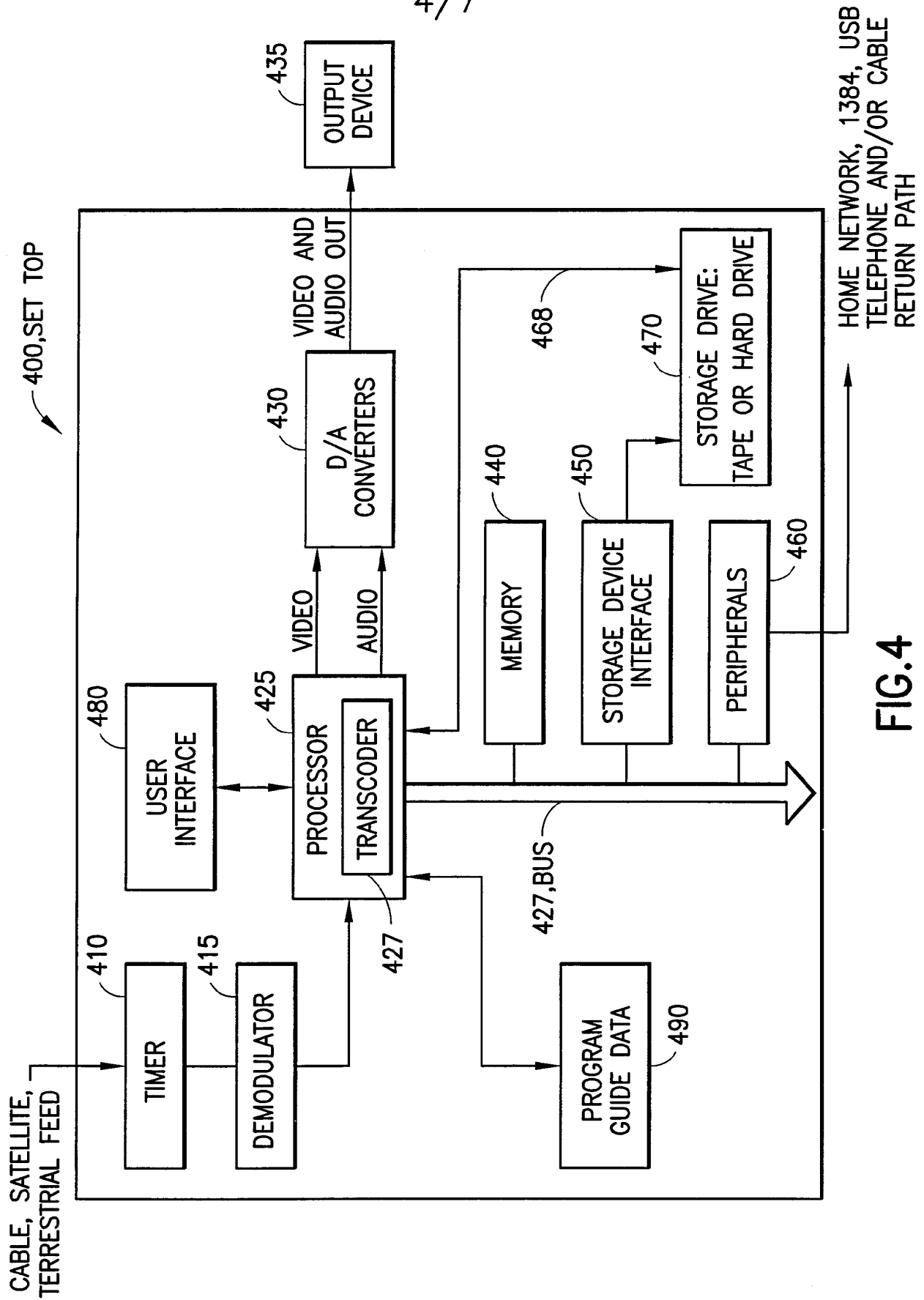


FIG.4

500

8 PM		9 PM	10 PM
ABC	MAJOR LEAGUE BASEBALL: YANKEES VS. METS (3 HOURS)		
TRAVEL	CRUISES (2 HOURS)		MIAMI'S BEACHES (1 HOUR)
PPV	TERMINATOR (CONTINUED)	MUSICAL SPECIAL (3 HOURS)	
FOX	COMEDY (1 HOUR)	SITCOM (1 HOUR)	LOCAL NEWS (1 HOUR)

SELECT A PROGRAM TO VIEW OR RECORD

FIG.5(a)

6/7

550

YOU HAVE SELECT "CRUISES"

PLEASE SELECT ONE:

1. VIEW
2. RECORD
3. VIEW AND RECORD
4. EXIT

FIG.5(b)

7/7

580

YOU HAVE CHOSEN TO RECORD "CRUISES"

THE RUN TIME IS 2 HOURS.

PLEASE SELECT A RECORD QUALITY:

HOURS OF STORAGE THAT WILL REMAIN:

- | | |
|-----------|---------|
| 1. HIGH | 3 HOURS |
| 2. MEDIUM | 6 HOURS |
| 3. LOW | 8 HOURS |
| 4. EXIT | |

FIG.5(c)

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/40659

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N5/00 H04N7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 923 814 A (BOYCE JILL MACDONALD) 13 July 1999 (1999-07-13) column 2, line 14 -column 5, line 2 column 5, line 37 -column 12, line 65 column 34, line 21 -column 41, line 35 abstract; figures 6,9 ---	1-23
A	BOYCE J M: "DATA SELECTION STRATEGIES FOR DIGITAL VCR LONG PLAY MODE" DIGEST OF TECHNICAL PAPERS OF THE INTERNATIONAL CONFERENCE ON CONSUMERELECTRONICS (ICCE),US,NEW YORK, IEEE, 21 June 1994 (1994-06-21), pages 32-33, XP000503953 ISBN: 0-7803-1454-9 the whole document --- -/--	1-23

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

G document member of the same patent family

Date of the actual completion of the international search

25 January 2001

Date of mailing of the international search report

02/02/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040. Tx. 31 651 epo nl.
Fax: (+31-70) 340-3016

Authorized officer

La, V

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/40659

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 627 854 A (DAE WOO ELECTRONICS CO LTD) 7 December 1994 (1994-12-07) column 2, line 34 -column 4, line 23 abstract; figures 1,2 ----	1-23
A	US 5 933 500 A (BRIDGEWATER KEVIN ELLIOTT ET AL) 3 August 1999 (1999-08-03) column 2, line 66 -column 3, line 51 abstract; figure 1 ----	1-23
A	US 5 477 397 A (NAIMPALLY SAIPRASAD V ET AL) 19 December 1995 (1995-12-19) abstract; figure 2 ----	1-23
A	BJOERK N ET AL: "TRANSCODER ARCHITECTURES FOR VIDEO CODING" IEEE TRANSACTIONS ON CONSUMER ELECTRONICS, IEEE INC. NEW YORK, US, vol. 44, no. 1, 1 February 1998 (1998-02-01), pages 88-98, XP000779254 ISSN: 0098-3063 section 3. "The basic video transcoder" section 4. "The modes of transcoding" abstract; figures 3-5 -----	1-23

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/40659

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5923814 A	13-07-1999	US 5887115 A	23-03-1999
		US 5805762 A	08-09-1998
		US 5444575 A	22-08-1995
		US 5673358 A	30-09-1997
		US 5778143 A	07-07-1998
		US 5717816 A	10-02-1998
		US 5729648 A	17-03-1998
		US 5726711 A	10-03-1998
		US 6023553 A	08-02-2000
		US 5493456 A	20-02-1996
		US 5668918 A	16-09-1997
EP 0627854 A	07-12-1994	KR 9514858 B	16-12-1995
		DE 69421847 D	05-01-2000
		DE 69421847 T	20-04-2000
		JP 7023339 A	24-01-1995
		US 5497239 A	05-03-1996
US 5933500 A	03-08-1999	AU 3213397 A	05-01-1998
		BR 9709508 A	10-08-1999
		CN 1226359 A	18-08-1999
		EP 0903038 A	24-03-1999
		WO 9746017 A	04-12-1997
		AU 3150797 A	05-01-1998
		AU 3150897 A	05-01-1998
		AU 3209497 A	05-01-1998
		AU 716349 B	24-02-2000
		AU 3213297 A	05-01-1998
		BR 9709409 A	10-08-1999
		BR 9709410 A	10-08-1999
		BR 9709420 A	10-08-1999
		BR 9709494 A	10-08-1999
		CN 1226354 A	18-08-1999
		CN 1226355 A	18-08-1999
		CN 1226356 A	18-08-1999
		CN 1226357 A	18-08-1999
		EP 0903033 A	24-03-1999
		EP 0903034 A	24-03-1999
		EP 0903035 A	24-03-1999
		EP 0903036 A	24-03-1999
		JP 2000512095 T	12-09-2000
		PL 330219 A	10-05-1999
		WO 9746007 A	04-12-1997
		WO 9746008 A	04-12-1997
		WO 9746009 A	04-12-1997
		WO 9746010 A	04-12-1997
		US 5844595 A	01-12-1998
		US 5838873 A	17-11-1998
		US 5844478 A	01-12-1998
		US 5754651 A	19-05-1998
US 5477397 A	19-12-1995	CA 2125334 A	09-12-1994
		DE 69425401 D	07-09-2000
		DE 69425401 T	11-01-2001
		EP 0629085 A	14-12-1994
		JP 7075112 A	17-03-1995
		CA 2115976 A	24-08-1994
		DE 69424582 D	29-06-2000

INTERNATIONAL SEARCH REPORT

information on patent family members

Intern. Application No

PCT/US 00/40659

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5477397 A		DE 69424582 T	18-01-2001
		EP 0613297 A	31-08-1994
		JP 7059047 A	03-03-1995
		US 5589993 A	31-12-1996
<hr/>			